STUDIES IN THE ADAPTATION AND EVOLUTION OF THE AUSTRALASIAN FAUNA

A collection submitted for the Degree of Doctor of Science

in the University of Adelaide

by

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Details of research activities relating to submission

My PhD research centred on the mechanisms used by a lizard to cope with temperature extremes and water stresses in Western Australia (5, 6, 23). S.D. Bradshaw was one of the supervisors of this thesis, otherwise the work is my own.

When I began work in my present laboratory in 1972, I extended this work to include studies of response to water stress in Australian desert mammals (1, 11). These studies followed a standard procedure and were unremarkable other than showing the very high tolerance of some Australian desert rodents to water stress. Here, the work is my own except for C.H.S. Watts overseeing the animal breeding colonies and providing background knowledge of Australian rodent biology.

During the course of this work it occurred to me that while many studies had been made of responses of animals to water stress, no studies had been made of the mechanisms a lactating female desert animal might use to conserve water. This led to studies of the water balance of lactation in desert animals (4, 7). Here, all the work reported is my own except that again C.H.S. Watts oversaw the animal breeding colonies, while L. Spencer and C. Pollard provided technical assistance.

This work showed that desert mammals were indeed better able to sustain lactation in the face of water-stress, but the exact mechanism used eluded me. The solution to this dilemma came with the discovery of water recycling in lactating mammals (2, 10). Here, the female drinks the urine of the lactating young, a feature which returns the water problem to the mother, whose kidney copes with the problem. Because adult desert mammals have such a high capacity to handle these problems (1), they are better able to sustain lactation under water-stress. This work was done with B. Green who, in a remarkable coincidence, independently discovered water-recylcing in dingoes. Here, I did the work on marsupials and rodents, and B. Green did the work on dingoes. Subsequent studies were aimed at determining precisely how efficient this mechanism was in rodents, and its effect on water balance of the mother (24, 26, 39). Here, the work is my own except for C.H.S. Watts overseeing the animal husbandry, L. Spencer providing technical assistance, and S. Elhay providing mathematical and computational advice and analysis.

As a result of this work, it soon became apparent that, in order to adequately interpret the adaptations I was observing, I needed to know more of the evolutionary history of the rodents of Australia. A number of modern genetic techniques had become available for such studies, and so I applied the techniques of chromosomes (8, 13, 17, 18, 19, 27, 31, 32, 33, 47, 52, 53), and allozyme electrophoresis (12, 16, 20, 43, 63, 67) to investigate the evolution of the Australian rodents.

All of the work reported in the chromosome papers 8, 13, 17, 18, 19 is my own except for C.H.S. Watts overseeing the husbandry of laboratory animals and supervising the collection of animals from the field, A.C. Robinson and J.F. Robinson collecting the animals from the field, and J.T. Hogarth providing technical assistance. The work reported in 31, 32, 33, 47, 52 and 53 is my own except that W.G. Breed conducted the reproductive anatomy and physiology in 31 and 33, M. Gelder and A. Jahnke provided technical assistance, C.H.S. Watts oversaw collection of animals from the field, and in 32, M. Adams conducted the electrophoresis. The allozyme studies represent my own work except for the following contributions: S. Cole provided technical assistance in 12, 16, 20, 43; J. Covacevich supplied the animals in 12; C.H.S. Watts supervised the collection and husbandry of animals in 16, 20, 43 and 67; and M. Adams conducted the electrophoresis in 43, 63 and 67. For 63, my contribution involved mathematical analysis of the electrophoretic data.

These studies led to a much clearer understanding of the evolutionary history of this group, summarized in a number of papers (41, 44, 61). In 44, I wrote the section on phylogenetic history and taxonomy.

A group whose evolutionary history is now very well known as a result of this work is the Australian Rattus, and consequently this group has proved useful for testing evolutionary hypotheses on DNA evolution (29, 34, 35, 60, 81, 82). My contribution to these studies was to conduct the genetic crosses, supply the tissue samples, and provide the evolutionary interpretations of the data.

The studies of evolution in the Australian rodents showed how morphological evolution and genetic evolution were often decoupled. Hence it became apparent that a full understanding of the evolutionary history of Australian vertebrates would only come from the application of these modern genetic techniques. I therefore extended the genetic approach to include other vertebrates such as marsupials (36, 42, 49, 56, 57, 71, 72, 74), bats (37, 45, 75, 76, 77), dingoes (21), birds (46, 54), and snakes (65, 66). In 21, 36, 37, 42, 45, 46, 49, 54, 57, 75, 76, and 77 I coordinated the research and acted as the major writer of the papers. Most of these papers are co-authored by M. Adams, who did the electrophoretic work. Papers 56, 71 and 72 represent my own work with the technical assistance of J. Birrell and M. Krieg, while T. Flannery and K. Aplin provided samples for 71 and assisted with the manuscript preparation. In 65, I wrote all sections except that on immunodiffusion, while for 66 I conducted the microcomplement analyses and phylogenetic analysis. In 74, I wrote the sections on chromosomes and provided the albumin immunologic data and analysis.

The results of these studies may be generally summarized as follows:-

1) Among the Australian rodents, marsupials and bats there are many "sibling" species. That is, species that are so similar at the morphological level that their specific distinctiveness was not recognised until the genetic studies had been conducted. Indeed, as a result of this work, over 20 new species of mammals have been added to the Australian list since the publication of Strahan's "Complete Book of Australian Mammals" in 1983.

2) Sibling species are themselves a manifestation of the decoupling of genetic and morphological evolution i.e. genetic evolution proceeds to the point of speciation but morphological evolution is undetected. The studies of dingoes, birds and snakes showed the opposite extreme - of rapid morphological evolution with little genetic evolution. Thus dingoes and domestic dogs are indistinguishable at the molecular genetic level, yet are morphologically distinct. Among the birds and snakes, morphologically very distinct species are very similar at the genetic level.

3) A large body of evidence suggests that evolution at the molecular genetic level proceeds at a relatively constant rate. Therefore molecular genetic evolution can be used as a "clock" to date

past evolutionary events. When the "molecular clock" concept is applied to Australian vertebrates using the data I have accumulated, some surprising results emerge. For example, the Australian elapid snakes (the "poisonous snakes") have a very recent history in Australia. They appear to be only distantly related to the cobras of India and the mambas of Africa, and to have evolved here from sea-snakes a mere 7 million years ago. The molecular genetic studies of marsupials are similarly allowing dates to be placed on events in their evolutionary history.

As a result of these studies, I have developed considerable expertise in the areas of genetic approaches to studying evolutionary history (28, 62, 70, 73, 80), culminating in co-authorization of a book on allozyme electrophoresis (69). For 28, the basic idea and the writing of the paper were shared equally by B.J. Richardson and myself. Papers 62, 70 and 73 represent my own work with Adams supplying critical comments for 62 and 70. The book (69) was a joint effort, equally among the three authors.

Given the level of decoupling of morphological and genetic evolution seen in vertebrates, it seemed that the phenomenon might be even more apparent in invertebrates, particularly among the parasites. This is a major area of my current research, and early indications support the hypothesis (64, 68, 79, 83). I conceived the idea of the study in 64, and coordinated the project, while in 68, 79 and 83 the idea of the project was mine.

With the revolution currently occurring in the field of molecular biology, it is apparent that much of the DNA technology being developed will prove to be valuable for evolutionary studies. It is in this area that my future research efforts are being concentrated. I have been involved in one such study (78), where I conducted the phylogenetic analyses of the data.

PUBLICATIONS: P.R. BAVERSTOCK

(Those submitted as part of this thesis marked with an asterisk)

1974

*1. Baverstock, P.R. and Watts, C.H.S. (1974). Water balance and kidney function in some rodents endemic to Australia. Lab. Anim. Sci. 24, 743-751.

1975

*2. Baverstock, P.R. and Green, B. (1975). Water recycling in lactation. Science 187, 657-658.

3. Baverstock, P.R. and Olner, A. (1975). Incomplete recessiveness of albinism in *Rattus villosissimus*. Search 6, 509.

*4. Baverstock, P.R. and Watts, C.H.S. (1975). Water balance of small lactating rodents - I. *Ad libitum* water intakes and effects of water restriction on growth of young. Comp. Biochem. Physiol. 50A, 819-825.

*5. Baverstock, P.R. (1975). Effect of variations in rate of growth on physiological parameters in the lizard *Amphibolurus ornatus*. Comp. Biochem. Physiol. 51A, 619-631.

*6. Baverstock, P.R. and Bradshaw, S.D. (1975). Variation in rate of growth and adrenal corticosteroidogenesis in field and laboratory populations of the lizard *Amphibolurus ornatus* Comp. Biochem. Physiol. 52A, 557-565.

*7. Baverstock, P.R., Spencer, L. and Pollard, C. (1975). Water balance of small lactating rodents. II. Concentration and composition of milk of females on ad libitum restricted water intakes. Comp. Biochem. Physiol., 53A, 47-52.

*8. Baverstock, P.R., Watts, C.H.S. and Hogarth, J.T. (1975). Karyotypic data and the specific status and taxonomic affinities of *Rattus villosissimus* and *R. sordidus*. Aust. J. Zool. 23, 293-294.

9. Baverstock, P.R. and Aslin, H. (1975). A new marsupial. Hemisphere 19, 20-23.

1976

*10. Baverstock, P.R., and Green, B. (1976). Exchange of water during lactation. Science, 191, 409-410.

*11. Baverstock, P.R. (1976). Water balance and kidney function in four species of *Rattus* from ecologically diverse environments. Aust. J. Zool. 24, 7-17.

*12. Baverstock, P.R., Hogarth, J.T., Cole, S. and Covacevich, J. (1976). Biochemical and karyotypic evidence for the specific status of the rodent *Leggadina lakedownensis* Watts. Trans. R. Soc. S. Aust. 100, 109-112.

*13. Baverstock, P.R., Watts, C.H.S. and Hogarth, J.T. (1976). Heterochromatin variation in the Australian rodent *Uromys caudimaculatus*. Chromosoma (Berl), 57, 397-403.

14. Robinson, A.C., Robinson, J.F., Watts, C.H.S. and Baverstock, P.R. (1976). The Shark Bay mouse _Pseudomys praeconis_ and other mammals on Bernier Island, Western Australia. _W. Aust. Nat._ 13, 149-155.

15. Robinson, J.F., Robinson, A.C., Watts, C.H.S. and Baverstock, P.R. (1976). Notes on rodents and marsupials and their ecto-parasites collected in Australia in 1974/75. _Trans. R. Soc. S.Aust._ 102, 59-70.

1977

*16. Baverstock, P.R., Watts, C.H.S. and Cole, S.R. (1977). Electrophoretic comparisons between the allopatric populations of five Australian Pseudomyine rodents (Muridae). _Aust. J. Biol. Sci._ 30, 471-485.

*17. Baverstock, P.R., Watts, C.H.S. and Hogarth, J.T. (1977). Polymorphism of the X-chromosome, Y-chromosome and autosomes in the Australian hopping mice, _Notomys alexis_, _N. cervinus_ and _N. fuscus_ (Rodentia,Muridae). _Chromosoma_ (_Berl_.) 61, 243-256.

*18. Baverstock, P.R., Watts, C.H.S. and Hogarth, J.T. (1977). Chromosome evolution in Australian rodents I. The Pseudomyinae, Hydromyinae and _Uromys_/_Melomys_ group. _Chromosoma_ (_Berl_) 61, 95-125.

*19. Baverstock, P.R., Watts, C.H.S., Robinson, A.C. and Robinson, J.F. (1977). Chromosome evolution in Australian rodents II. The _Rattus_ group. _Chromosoma_ (_Berl_) 61, 227-241.

*20. Baverstock, P.R., Watts, C.H.S. and Cole, S.R. (1977). Inheritance studies of glucose phosphate isomerase, transferrin and esterases in the Australian hopping mice Notomys alexis, N. cervinus, N. mitchellii and N. fuscus (Rodentia: Muridae). Anim. Blood Grps biochem. Genet. 8, 3-12.

*21. Cole, S.R., Baverstock, P.R. and Green, B. (1977). Lack of genetic differentiation between domestic dogs and dingoes at a further 16 loci. Aust. J. Exp. Biol. Med. Sci. 55, 229-232.

22. Watts, C.H.S., Baverstock, P.R. and Cole, S.R. (1977). Genetic similarities and differences between sublines of certain inbred strains of mice held within Australia. Aust. J. Exp. Biol. Med. Sci. 55, 347-353.

*23. Baverstock, P.R. (1978). The probable basis of the relationship between growth rate and winter mortality in the lizard Amphibolurus ornatus (Agamidae). Oecologia 37, 101-107.

1979

*24. Baverstock, P.R. and Elhay, S. (1979). Water-balance of small lactating rodents - IV. Rates of milk production in Australian rodents and the guinea pig. Comp. Biochem. Physiol. 63A, 241-246.

25. Baverstock, P.R. (1979). A three year study of the mammals and lizards of Billiatt Conservation Park in the Murray Mallee, South Australia. Sth. Aust. Nat. 53, 52-58.

*26. Baverstock, P.R., Watts, C.H.S. and Spencer, L. (1979). Water-balance of small lactating rodents - V. The total water-balance picture of the mother-young unit. Comp. Biochem. Physiol. 63A, 247-252.

*27. Watts, C.H.S., Baverstock, P.R., Adams, M., Gelder, M. and Jahnke, A. (1979). Mapping genes to chromosomes in the genus Rattus. Rat Newsletter 5, 28-29.

*28. Baverstock, P.R., Cole, S.R., Richardson, B.J. and Watts, C.H.S. (1979). Electrophoresis and cladistics. Syst. Zool. 28, 214-219.

1980

*29. Miklos, G.L.G., Willcocks, D.A., and Baverstock, P.R. (1980). Restriction endonuclease and molecular analyses of three rat genomes with special reference to chromosome rearrangement and speciation problems. Chromosoma (Berl) 76, 339-363.

30. Baverstock, P.R. and Ford, G.E. (1980). Sheep sarcosporidioses: Genetic differentation of sarcocystis with isoenzymes. Proc. Aust. Soci. Parasitol. 24th Conf. Flinders Univ. Adelaide.

*31. Baverstock, P.R., Breed, W.G., Gelder, M. and Jahnke, A. (1980). Ovarian histology of two XO murid rodents from Australia. Aust. J. Exp. Biol. Med. Sci. 58, 607-613.

*32. Baverstock, P.R., Watts, C.H.S., Adams, M. and Gelder, M. (1980).

Chromosomal and electrophoretic studies of Australian Melomys (Rodentia:Muridae). Aust. J. Zool. 28, 553-574.

*33. Breed, W.G., Baverstock, P.R., Gelder, M. and Jahnke, A. (1980). A pseudohermaphroditic XY/XO mosaic Pseudomys australis (Rodentia:Muridae). J. Mamm. 61, 537-539.

*34. Gutman, G.A. and Baverstock, P.R. (1980). Multiple specificities of rat kappa chain allotypes in Australian Rattus. Abstract Fed. Proc. 39, 357.

*35. Gutman, G.A. and Baverstock, P.R. (1980). Rat kappa-chain allotypes III. Serological and genetic analysis of RI-1b cross-reactivity in Australian Rattus. Immunogenetics 11, 559-570.

*36. Adams, M., Baverstock, P.R. and Aslin, H.J. (1981). Inheritance of red cell glucose-phosphate isomerase in the Australian marsupial, Dasyuroides byrnei. Biochem. Genet., 19, 187-190.

1981

*37. Tidemann, C.R., Woodside, D.P., Adams, M. and Baverstock, P.R. (1981) Taxonomic separation of Eptesicus (Chiroptera: Vespertilionidae) in south-eastern Australia by discriminant analysis and electrophoresis. Aust. J. Zool. 29, 119-128.

38. Baverstock, P.R. and Watts, C.H.S. (1981). Native Australian mammals in biomedical research. J. Aust. Anim. Tech. Assoc., 6, 33-42.

*39. Baverstock, P.R., and Elhay, S. (1981). Water balance of small lactat rodents - III. Estimates of milk production and water recycling in lactating Mus musculus under various water regimes. J. Math. Biol. 13, 1-22.

40. Baverstock, P.R. (1981). Book review - 'Cytogenetics of the Black Rat' by T.H. Yosida. J. Mamm. 62, 866-867.

*41. Baverstock, P.R. (1981). Adaptations and evolution of the mammals of arid Australia. pp 175-178. In 'Evolution of the Flora and Fauna of Arid Australia'. Ed. Barker, W.R. and Greenslade, J.G.M.

*42. Baverstock, P.R., Archer, M., Adams, M. and Richardson, B.J. (1981). Genetic relationships among 32 species of Australian dasyurid marsupials. Pp. 641-650. In 'Carnivorous Marsupials', Ed. M. Archer. Roy. Zool. Soc. of N.S.W., Sydney.

*43. Baverstock, P.R., Watts, C.H.S., Adams, M. and Cole, S.R. (1981). Genetical relationships among Australian rodents (Muridae). Aust. J. Zool. 29, 289-303.

*44. Lee, A.K., Baverstock, P.R., and Watts, C.H.S. (1981). Rodents - The late invaders. Pp. 1523-1548. In 'Ecological Biogeography of Australia'. A. Keast (Ed.) Junk: The Hague.

1982

*45. Adams, M., Baverstock, P.R., Tidemann, C.R. and Woodside, D.P. (1982).

Large genetic differences between sibling species of bats, Eptesicus, from Australia. Heredity 48, 435-438.

*46. Baverstock, P.R., Adams, M., Polkinghorne, R. and Gelder, M. (1982). A sex-linked enzyme in birds. - Z-chromosome conservation but no dosage compensation. Nature 296, 763-766.

*47. Baverstock, P.R., Gelder, M. and Jahnke, A. (1982). Cytogenetic studies of the Australian rodent, Uromys caudimaculatus, a species showing extensive heterochromatin variation. Chromosoma, (Berl.) 84, 517-533.

1983

48. Baverstock, P.R. (1983). Pale field-rat, Rattus tunneyi in Strahan Ed. 'Complete book of Australian mammals', Pp451. Angus and Robertson, Publ. Sydney.

*49. Baverstock, P.R., Adams, M., Archer, M., McKenzie, N. and How, R. (1983). An electrophoretic and chromosomal study of the dasyurid genus Ningaui Archer. Aust. J. Zool. 31, 381-392.

50. Baverstock, P.R., Adams, M., Gutman, G.A., McNeilage, J. and Heslop, B.F. (1983). Polymorphism for Aldehyde dehydrogenase (Ahd) and Alkaline phosphatase (Akp) in (AS X DA) F_1 backcross rats. Transp. Proc. 15, 1677-8.

51. Baverstock, P.R., Adams, M., Maxson, L.R. and Yosida, T.H. (1983). Genetic differentiation among karyotypic forms of the black rat, Rattus rattus. Genetics 105, 969-983.

*52. Baverstock, P.R., Gelder, M. and Jahnke, A. (1983). Chromosome evolution in Australian Rattus - G-banding and hybrid meiosis. Genetica 60, 93-103.

*53. Baverstock, P.R., Watts, C.H.S., Gelder, M. and Jahnke, A. (1983). G-banding homologies of some Australian rodents. Genetica 60, 105-117.

1984

*54. Adams, M., Baverstock, P.R., Saunders, D.A., Schodde, R. and Smith, G.T. (1984). Biochemical systematics of the Australian cockatoos (Psittaciformes:Cacatuinae). Aust. J. Zool. 32, 363-367.

55. Adams, M., Baverstock, P.R., Watts, C.H.S. and Gutman, G.A. (1984). Enzyme markers in inbred rat strains: genetics of new markers and strain profiles. Biochem. Genet. 22, 611-629.

*56. Baverstock, P.R. (1984). The molecular relationships of Australian Possums and Gliders. Pages 1-8. In "Possums and Gliders", Ed. by A.P. Smith and I.D. Hume, Australian Mammal Society, Sydney.

*57. Baverstock, P.R., Adams, M. and Archer, M. (1984). Electrophoretic resolution of species boundaries in the Sminthopsis murina complex (Dasyuridae). Aust. J. Zool. 32, 823-832.

58. Bender, K., Adams, M., Baverstock, P.R., _et al_. (1984). Biochemical markers in inbred strains of the rat (_Rattus norvegicus_). _Immunogenetics_ 19, 257-266.

59. Bender, K., Gunther, E., Adams, M., Baverstock, P.R. _et al_. (1984). Characterization of rat inbred strains: Report of a joint programme and details on further markers. _Rat Newsletter_.

*60. Frank, M.B., Besta, R.M., Baverstock, P.R. and Gutman, G.A. (1984). Kappa-chain constant-region gene sequences in genus _Rattus_: Coding regions are diverging more rapidly than noncoding regions. _Mol. Biol. Evol._ 1, 489-501.

*61. Baverstock, P.R., (1984). Australia's living rodents: a restrained explosion. Pp 913-919. In "Vertebrate Zoogeography and Evolution in Australia" Archer, M. and Clayton, G. eds. Hesperian Press, Perth.

*62. Baverstock, P.R. and Adams, M. (1984). Isozyme electrophoresis and species identification. Pp 428-431. In 'Australian Applied Entomological Research'. Ed. by P. Bailey and D. Swincer.

*63. Kitchener, D.J., Adams, M. and Baverstock, P.R. (1984). Redescription of _Pseudomys bolami_ Troughton, 1932 (Rodentia: Muridae). _Aust. Mammal_. _7_: 149-159.

<u>1985</u>

*64. Baverstock, P.R., Adams, M. and Beveridge, I. (1985). Biochemical differentiation in bile duct cestodes and their marsupial hosts. _Mol. Biol. Evol._ 2: 321-337.

*65. Baverstock, P.R., and Schwaner, T.D. (1985). Phylogeny of Australian elapid snakes - the genetical approach. Pp 159-164. In 'Biology of Australian Frogs and Reptiles'. Ed. by G. Grigg, R. Shine and H. Ehmann. Royal Zoological Society of New South Wales.

*66. Schwaner, T.D., Baverstock, P.R., Dessauer, H.C. and Mengden, G.A. (1985). Immunological evidence for the phylogenetic relationships of Australian elapid snakes. Pp 177-184. In 'Biology of Australasian Frogs and Reptiles' ed. by G. Grigg, R. Shine and H. Ehmann. Royal Zoological Society of New South Wales.

*67. Baverstock, P.R., Adams, M. and Watts, C.H.S. (1986). Biochemical differentiation among karyotypic forms of Australian <u>Rattus</u>. <u>Genetica</u> 71, 11-22..

*68. O'Donoghue, P.J., Adams, M., Dixon, B.R., Ford, G.E., and Baverstock, P.R. (1986). Morphological and biochemical correlates in the characterization of <u>Sarcocystis</u> spp. <u>J. Protozool.</u> <u>33</u>: 114-121.

<u>1986</u>

*69. Richardson, B.R., Baverstock, P.R. and Adams, M.A. - BOOK - 'Allozyme Electrophoresis - A Handbook for Animal Systematics and Population Studies'. Academic Press, Sydney. 410 pages.

<u>1987</u>

*70. Baverstock, P.R. and Adams, M. (1987). Comparative rates of molecular, chromosomal and morphological evolution in some Australian vertebrates. In "Rates of Evolution" ed by K. Campbell and M. Day, Allen and Unwin, London

*71. Baverstock, P.R., Flannery, T., Aplin, K., Birrell, J. and Krieg, M. (1987). Albumin immunologic relationships of the bandicoots (Perameloidea:Marsupialia) - a preliminary report. Pages ..... in 'Bandicoots' ed. P.R. Brown and A.G. Lyne, Australian Mammal Soc., Sydney. (In Press).

*72. Baverstock, P.R., Birrell, J. and Krieg, M. (1986). Albumin immunologic relationships among Australian possums: a progress report. Pages .... In 'Possums and Opossums: Studies in Evolution' ed. M. Archer. Surrey Beatty and Sons and the Royal Zoological Society of New South Wales, Sydney. (In Press).

*73. Baverstock, P.R. (1986). Modern taxonomic character sets. In "Fauna of Australia, Vol. 1B. Mammalia." D.W. Walton and G.R. Dyne, Eds. Australian Government Publishing Service. (In Press).

*74. Clemens, W.A., Baverstock, P.R., and Richardson, B.J. (1987). Biogeography and phylogeny of Metatheria. In 'Fauna of Australia. Vol. 1B. Mammalia" D.W. Walton and G.R. Dyne, eds. Australian Government Publishing Services (In Press).

<u>1987</u>

*75. Adams, M., Baverstock, P.R., Watts, C.H.S. and Reardon, T. (1987).

Electrophoretic resolution of species boundaries in Australian Micirochiroptera. I. Eptesicus (Chiroptera: Vespertilionidae). Aust. J. Biol. Sci. 40, 143-162.

*76. Adams, M., Baverstock, P.R., Watts, C.H.S., and Reardon, T. (1987). Electrophoretic resolution of species boundaries in Australian Microchiroptera. II. The Pipistrellus/Falsistrellus group (Chiroptera: Vespertilionidae). Aust. J. Biol. Sci. 40, 163-170.

*77. Baverstock, P.R., Adams, M., Reardon, T. and Watts, C.H.S. (1987). Electrophoretic resolution of species boundaries in Australian Microchiroptera III. The Nycticeiini - Scotorepens and Scoteanax (Chiroptera: Vespertilionidae). Aust. J. Biol. Sci. (In Press).

*78. Johnson, A.M., Murray, P.J., Illana, S., and Baverstock, P.R. (1987). Rapid nucleotide sequence analysis of the small ribosomal RNA subunit of Toxoplasma gondii: Evolutionary implications for the Apicomplexa. Molec. Biochem. Parasitol. (In Press).

*79. Andrews, R.H., Handman, E., Adams, M., Baverstock, P.R., and Mitchell, G.F. (1987). Genetic characterization of Leishmania isolates at 37 enzyme loci. Int. J. Parasitol. (In Press).

*80. Baverstock, P.R. (1987). Applications of molecular genetic techniques in Zoology. Aust. Zool. Reviews (In Press).

81. Gutman, G.A., Besta, R.M., Frank, M.B. and Baverstock, P.R. (1987). Duplication of J_k_ genes within genus _Rattus_. _Immunogenetics_ (In press).

82. Frank, M.B., Besta, R.M., Baverstock, P.R., and Gutman, G.A. (1987). The structure and evolution of immunoglobulin kappa chain constant region genes in the genus _Rattus_. _Molec. Immunol._ (In press).

83. Ford, G.E., Fayer, R., Adams, M., O'Donoghue, P.J., Dubey, J.P., and Baverstock, P.R. (1987). Genetic characterization by isoenzyme markers of North American and Australasian isolates of species of _Sarcocystis_ (Protozoa:Apicocomplexa) from mice, sheep, goats and cattle. _Syst. Parasitol._ 9, 163-167.